

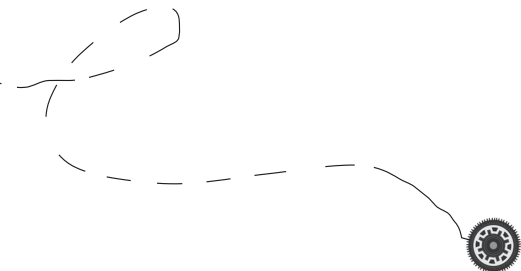
FRANKENSTEIN'S CAT



Cuddling Up to Biotech's Brave New Beasts



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FRANKENSTEIN'S CAT

Introduction



In China, the world's manufacturing powerhouse, a new industry is taking shape: the mass production of mutant mice. Peek into the 45,000 mouse cages at Shanghai's Fudan University and you'll see a growing collection of misfits. By randomly disabling the rodents' genes, the scientists here are churning out hundreds of odd animals, assembly-line style. They have created mice studded with skin tumours and mice that grow tusks. There's a mouse with male-pattern baldness, hair everywhere save for a lonely bare spot on its head. Some of the mice have strange behavioural quirks – they endlessly bury marbles, for instance, or make only left turns. One strain ages at warp speed. Another can't feel pain.

While some of the rodents have obvious abnormalities, others reveal their secrets over time. One variety appears normal on the outside, with thick white fur and healthy pink ears and noses. But the animals are klutzes. They are clumsy and spectacularly uncoordinated. They fail miserably when researchers put them through their paces at a special rodent boot camp. In one test, the mice are

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tasked with standing on top of a rotating rod for as long as they can manage, the rodent equivalent of a log-rolling challenge. It's not an easy undertaking, but normal mice eventually find their footing. The mutant mice never do. They also have trouble balancing on a narrow wooden beam and keeping their grip when suspended, upside down, from a wire screen. And they have strange gaits – taking abnormally wide steps and holding their tails at odd angles, curved up towards the ceiling, instead of letting them simply drag along the floor behind them, as mice usually do.

Even stranger, perhaps, are the Lonely Hearts Club mice. The males of this strain look like regular rodents, but the females consistently refuse to mate with them. The poor guys, lacking some certain *je ne sais quoi*, simply have no sex appeal, and they are rejected time and time again.

These mice are just a small sample of the more than 500 different kinds of mutants the Fudan team has created. Ultimately, the researchers hope to create *100,000* strains of modified mice, each eccentric in its own way. It would be enough to fill a carnival side-show thousands of times over.

As long as we're dreaming up animal sideshows, we needn't stop with peculiar mice. Science has given us a whole new toolbox for tinkering with life, and we have the power to modify animals in profound new ways. We are editing their genetic codes, rebuilding their broken bodies, and supplementing their natural senses. Tabloids and broadsheets alike frequently herald the birth of strange new creatures: *Bionic beetles! Glowing cats! Spider goats! Roborats!* The breakthroughs are simultaneously astounding and puzzling. What *are* these creatures exactly? What do they look like? Who's creating them, and why? And are these animals really so novel?

Indeed, we have a long history of refashioning animal bodies. Take the varied members of the species *Canis lupus familiaris* – the modern dog – which are products of millennia of life with humans and bear little resemblance to their ancestors, grey wolves. Exactly how this dog domestication began is a subject of intense debate. Some scientists suggest that we deliberately set out to acquire canine companions, adopting wild wolf pups. Others hypothesize that hungry wolves, attracted to the bones, meat scraps and other rubbish produced by early humans, approached our camps on their own terms, and that our tolerance of the least threatening interlopers gave rise to future generations of human-friendly canines. Either way, as wolves became part of human society, moving from cold ground to warm hearth, they lost many of the traits they needed to survive in the wild. Their bodies and heads shrank, their faces and jaws grew more compact, and their teeth decreased in size.

As our relationship with canines developed, we began to breed them more carefully, moulding dogs that excelled at specific tasks. We created the bulky, barrel-chested mastiff to guard our homes, and the dachshund, a wiggly salami of a dog, to shimmy into badger burrows. The diversity among modern dogs is so astounding that the thirty thousand dogs that strut their canine stuff at Crufts, the largest dog show in the world, don't even look like members of the same species. One year, the 'Best in Show' contenders included King, a hound with a deer's build, all legs and lean muscle, and Ricky, a tiny black-and-white fluff ball who could stand easily underneath King's smooth brown belly. They shared the ring with Donny – a standard poodle whose shaved grey haunches were set off by a thick white mane – and Cruella, an Old English sheepdog whose long, shaggy hair obscured all but the black dot that presumably served as her nose. Today, thanks to us, dogs are the most physically diverse species on Earth.

We've reshaped other species, too, turning scrawny chickens into plump broiler birds and bristly-haired wild sheep into producers of soft wool. The list goes on and on. We learned to breed animals that suited our every need, creating hunters, herders, guardians, food sources and companions. Over the course of generations, the members of many species diverged from their wild ancestors and took their place in a human world.

But selective breeding was a blunt instrument, one that required us to transform animals using educated guesswork, breeding desirable hounds together, over and over again, until a puppy we liked squirmed into the world. It took thousands of years to turn wolves into dogs. Now we can create novel organisms in years, months, even days.

Today, the tools of molecular biology allow us to target one specific gene, to instantly turn it on or off, to silence or amplify its effects. For instance, the researchers at Fudan University are creating their stunning array of strange mice simply by knocking out a single gene at a time. To do so, they're relying on a special genetic tool called a transposon or a 'jumping gene', a segment of DNA capable of hopping around the genome. When the scientists inject a transposon into a mouse embryo, this foreign piece of DNA inserts itself into a random place in the rodent's genome, disabling whatever gene it finds there. But the real beauty of the system is that when this mouse grows up and mates, the transposon jumps to a different location in the genome of its pups, sabotaging a new gene. With each mating, researchers have no idea where the transposon will end up, what gene it will disrupt, or what the ultimate effects will be. It's like throwing darts at a genetic dartboard. Blindfolded. Only when the pups are born, and start exhibiting various abnormalities, do the scientists learn what part of the genome has gone haywire. The approach is allowing the researchers to create cages upon cages of novel mutants, simply by playing matchmaker between their amorous

rodents. In some cases, the scientists are making furry freaks faster than they can figure out what's wrong with them.

We can also recombine genes in ways that nature never would – just consider a very curious cat skulking about New Orleans. With downy orange fur and a soft pink nose, the feline looks like your average tabby. But flick on a black light, and the cat becomes Mr. Green Genes, his nose turning from soft pink to electric lime, due to a bit of jellyfish DNA tucked into each of his cells. The insides of his ears and the whites of his eyes glow brightly, his face emerging from the dark like a modern-day Cheshire cat. (His son, Kermit, also glows green.)

Meanwhile, nearly two thousand miles away, a barn in Logan, Utah, is home to a strange herd of goats. Thanks to a pair of genes borrowed from a spider, each female goat produces milk that's chock-full of silk proteins. When the milk is processed in the lab, scientists can extract the spider proteins and spin them into silk.

Genetics isn't the only field providing us with the power to reengineer other species. Advances in electronics and computing make it possible to merge animal bodies with machines, to use tiny electrodes to hijack a rat's brain and guide the rodent, like a remote-controlled toy, through a complicated obstacle course. Breakthroughs in materials science and veterinary surgery are helping us build bionic limbs for injured animals, and we can train monkeys to control robotic arms with their thoughts. Today, our grandest science fiction fantasies are becoming reality.

Some of us may find our growing control over living, breathing beings to be unsettling. After all, biotechnology is the stuff of dystopian nightmares, and many an apocalyptic scenario has been constructed around crazy chimaeras or world-conquering cyborgs. Ethicists and activists worry about whether we should be altering other species

when we can't possibly get their consent. Some say that manipulating the planet's wild things – whether we're inserting genes or electrodes – is profoundly unnatural, causes animal suffering and turns other life-forms into commodities. Critics worry that our effort to remake the world's fauna is the worst example of human hubris, the expression of an arrogant desire to play God.

It's true that remaking other species according to our own wants and needs doesn't necessarily put animal welfare first. Selective breeding hasn't always turned out well for animals – we've saddled dog breeds with all sorts of hereditary diseases and created turkeys with such gigantic breasts that they can barely walk. And of course, biotechnology gives us new ways to do damage. The Fudan University scientists have created mouse embryos with defects so severe that they die in the womb. Some of their mutant mice are prone to tumours, or kidney disease, or neurological problems. One strain, unable to absorb nutrients from food, essentially starves to death.

In fact, a whole industry has sprung up to sell diseased lab animals to scientists, with numerous biotech companies hawking their unique creations. In October 2011, many of these companies converged on St. Pete Beach, Florida, for an international meeting of scientists who work with genetically modified organisms. Representatives from various biotech firms held court from booths ringing a hotel ballroom, advertising animals that had been engineered to suffer from all sorts of medical afflictions. One company was selling pigs with cystic fibrosis and cancer; a brochure from another outlined eleven available strains of rodents, from the NSE-p25 mouse, designed to display Alzheimer's-like symptoms, to the 11BHSD2 mouse, which has a tendency to drop dead of heart failure. (And just in case nothing there caught your fancy, one company's poster promised, 'You design the experiment, we'll design the mice'.) These companies aren't making sickly animals purely to be cruel, of course; studying these creatures yields valuable insight into human

disease. That's good news for us, but little consolation for a tumour-riddled rodent.

If there is peril here, there is also great promise. Biotechnology could do more for animals than it's given credit for. Sure, we can make animals sick, but we can also choose to deploy our species-shaping powers to help other species survive and thrive, to create healthier, happier, fitter critters, and some scientists are doing just that. With the sophisticated techniques at our fingertips, we may even be able to undo some of the damage we've done to other species, alleviating genetic disorders in dogs, for instance, or bringing wild animal populations back from the brink of extinction. Some forward-thinking philosophers are dreaming of more extreme interventions, such as boosting the brainpower of apes, and using genetic modification and electronic enhancement to help animals transcend the limits of their own bodies.

Right now all the options are open. Though biotechnology's strange new creatures are being created in the world's labs, they don't tend to stay there very long, and there are already cutting-edge animals living in fields, homes and nature reserves around the world. Before long, we may all be able to shop for animals the same way that scientists in Florida shopped for carefully engineered mice. Imagine a future in which we can each pick out the perfect animal from a catalogue of endless options, like something out of a Philip K. Dick novel. We could create an animal for everyone. Avid nighttime reader? How about your own Mr Green Genes so you can stay up late, reading by the light of the cat? For the twelve-year-old who has everything, skip the toy cars and planes at Christmas and wrap up a remote-controlled rodent. Equestrians could order up a foal with the same genes as the winner of last year's Epsom Derby, while sprinters could get themselves a Golden retriever whose artificial carbon-fibre legs would allow it to run as fast as a greyhound. The tools of biotechnology are becoming increasingly accessible to

the public; future generations of animal lovers may be able to design their own creatures without access to any fancy lab equipment or the least bit of advanced university training.

In the pages that follow, we'll go on a journey from petri dish to pet store, seeking out the revolutionary breeds of beasts that are taking their places in the world. We'll venture from the rocky shores of California to the foothills of the Scottish moors, from the canine clones that live in Korean labs to the pets that sleep in our homes. We'll delve into genes and brains, into work that seems frivolous and projects that are anything but. We'll meet an engineer who is turning beetles into stunt planes and a biologist who believes cloning just might save endangered species. And, of course, we'll come to know the animals themselves – from Jonathan, a sad sack of a seal with hundreds of online friends, to Artemis, a potentially life-saving goat whose descendants could one day take over Brazil.

Along the way, we'll puzzle through some larger questions. We'll probe how our contemporary scientific techniques are different from what's come before and whether they represent a fundamental change in our relationship with other species. We'll consider the relationship we have with animals and the one we'd like to have.

Most of us care deeply about some form of animal life, whether it's the cat or dog curled up on the sofa – 48 percent of Britons share their homes with pets of one species or another – the chickens laying our eggs, or some exotic predator fighting to survive as its habitat disappears. Now that we can sculpt life into an endless parade of forms, what we choose to create reveals what it is we want from other species – and what we want *for* them. But even if you feel no special affection for the creatures with whom we share this planet, our reinvention of animals matters for us, too. It provides a peek into our own future, at the ways we may start to

enhance and alter ourselves. Most of all, our grand experiments reveal how entangled the lives of human and nonhuman animals have become, how intertwined our fates are. Enterprising scientists, entrepreneurs and philosophers are dreaming up all sorts of projects that could alter the course of our collective future.

So what does biotechnology really mean for the world's wild things? And what do our brave new beasts say about us? Our search for answers begins with a tank of glowing fish.